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METHOD OF PRODUCING SOLAR CELLS

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Method of producing solar cells

The invention relates to an economically improved method of producing thin-layer solar cells, e.g. CdTe solar cells (CdTe = cadmium telluride). CdTe is used below merely as an example for all thin-layer solar cells.

CdTe and CdTe/CdS solar cells may be produced by various methods (US-5 304 499), common to all of which is heat treatment at at least 575°C, to achieve adequate efficiency. These temperatures allow the use only of expensive types of glass as supports. The use of glass as a support has the disadvantage that glass panels may be coated with CdTe only in discontinuous manner, irrespective of the coating method selected.

US-5 304 499 describes a method in which coating is carried out at temperatures of only 480 to 520°C, it thus being possible to use cheap types of glass ("window glass").

To this end, it is necessary for the glass firstly to be provided with a transparent, electrically conductive layer, e.g. of doped tin oxide. This is followed by a thin cadmium sulfide layer (CdS), to which the light-sensitive CdTe layer is then applied by sublimation at 480 to 520°C.

The apparatus required for application of the CdTe layer is complex and expensive: support material and CdTe source are held in such a way by opposing graphite blocks, which are heated to the necessary temperature, that the CdTe source is located only 2 to 3 mm from the support surface. Sublimation is then effected in a 0.1 mbar inert gas atmosphere, e.g. a nitrogen, helium, argon or hydrogen atmosphere. Large areas of CdTe-coated material for producing solar cells cannot be produced economically in this way.

H. Nishiwaki et al, Solar Energy Materials and Solar Cells 37 (1995) 295 to 306 use a polyimide film as support because this material has sufficient heat resistance in

comparison to polyethylene terephthalate (PET) and polyethylene naphthalate (PEN), because of its glass transition temperature of more than 500°C. Polyimide has the disadvantage to be insoluble in usual solvents and to be unable to be molten. It is therefore extremely difficult to be processed.

The known methods do not permit the use of easily produceable films of polymeric organic materials as supports.

The object of the invention was the economic production of a support with a photovoltaically active layer, e.g. a CdTe layer.

A method was surprisingly found, which permits the use of flexible polymeric films for coating with CdTe and annealing, without the polymeric supporting material being damaged by the high temperatures. In this way, a starting material is obtained for high efficiency solar cells.

The invention therefore provides a method of coating organic polymeric supporting materials with CdTe and annealing the CdTe layer of the materials thus coated, characterised in that the supporting material consists of a polymeric material with a glass transition temperature of from 90°C to 200°C and coating of the CdTe layer is carried out at temperatures below the glass transition temperature and annealing at temperatures of at least 250°C, in particular 400 to 600°C, by means of a laser for 0.01 to 1 s with an energy of 2 to 5000 watt per mm^2.

Preferably the supporting material is at least 60 μm, in particular 90 to 120 μm, thick and the CdTe layer is at most 30 μm, in particular 2 to 7 μm, thick.

Coating is carried out for example with an aqueous or solvent-containing CdTe suspension.

The material is then dried. Suitable coating methods are, for example, flooding and knife coating.

Annealing may be carried out several times; cooling phases are preferably provided between pairs of annealing steps.

Suitable polymers are PET and PEN. Prior to coating, the polymeric supporting material may be provided with a substrate layer, e.g. of indium-tin oxide, which improves the adhesion of the CdTe layer. The substrate layer should be transparent and electrically conductive.

Suitable lasers are, for example, argon lasers and yag lasers with frequency duplication.

Organic polymeric supporting materials are flexible and thus permit continuous coating using a suitable coating method.

It is especially advantageous for the CdTe particles to be particularly fine, in particular in the form of so-called nano-particles, i.e. particles whose average diameter lies in the nanometric range and amounts, for example, to from 3 to 5 nm.

In this case, it is expedient for an agent to be present during production of the nanoparticles which prevents agglomeration of the nanoparticles, e.g. tributylphosphane.

The invention also provides a solar cell comprising at least one CdTe layer at most 30 µm thick on a support, characterised in that the support is a polymeric organic material at least 60 µm thick and having a glass transition temperature of at least 90°C.

Owing to its flexibility, the polymeric organic support permits continuous coating by means of a coater, for example a meniscus or curtain coater, as known from the coating of photographic films.

Example

A film of PEN 100 μm thick and 100 cm wide is coated continuously with a suspension containing a dispersant and 31 g of cadmium telluride per litre. The coated film is then dried and the layer applied exhibits a dry layer thickness of 5 μm.

The film is annealed as follows:

The entire surface is irradiated with an Ar ion laser (wavelength 514 nm; power 7 W) with a focal point of 50 μm. The temperature is adjusted at from 400 to 450°C.

After annealing, the film exhibits light-dependent electrical resistance and is thus suitable for the production of a photovoltaic cell.

The supporting material is not damaged by exposure to the laser.